2. BARRIERS[1]

An overview of sector barriers to biopower technology development is examined below. The discussion begins with an analysis of technology barriers that must be overcome to achieve successful technology pathways leading to the commercialization of biomass conversion and feedstock technologies. Next, an examination of institutional barriers is presented which encompasses the underlying policies, regulations, market development, and education needed to ensure the success of biopower. This document draws upon recent insights contained in *The Biopower Roadmap* (to be published), which was developed through a series of three industry-led stakeholder workshops facilitated by the U.S. Department of Energy during the past year.[2]

Technology Barriers

Biomass is a very desirable fuel and feedstock because it is renewable, sustainable, and clean (generally does not contain many pollutant-forming species such as sulfur, nitrogen and heavy metals.) Biomass is also widely available throughout the world and amenable to conversion to a wide variety of useful forms. However, biomass, more so than virtually any other fuels or energy source, varies considerably in its elemental composition, energy content, and physical characteristics. It also contains species, such as alkali metals, that, while not considered pollutants, often cause mechanical problems, such as deposition and corrosion of heat transfer surfaces, in conversion systems. As such, it presents considerable technical challenges at virtually all phases of conversion to useful energy forms and products.

Combustion/Cofiring

Combustion has been, for the entire history of the human species, the most common method of extracting energy from biomass (other than food) either directly, in the form of heat and light from a fire, or indirectly through use of this heat to produce steam that turns electricity-generating turbines. Direct combustion of biomass to raise steam is used in all of the existing 7 GW of biomass generation plants in operation in the U.S. today.

Many types of biomass used for fuel contain alkali metal species such as sodium, potassium, and calcium. In a combustion environment, the combustion products of these species, chlorides, silicates, etc., can form deposits on heat transfer surfaces reducing heat transfer, and thus, overall plant efficiency. They can also accelerate the corrosion or erosion of the heat transfer surfaces. Both of these mechanisms increase the maintenance requirements of the power plant. When biomass is cofired with coal (even in small percentages), the biomass containing these alkali species can change the properties of the resulting mixed ash, which can have a significant impact on the coal plant's O&M costs or even operability.

In 1996, the Biopower Program funded a collaboration between Sandia, NREL, University of California at Davis, Foster Wheeler Development Corp., Thomas R. Miles Consulting Design Engineers, and the U.S. Bureau of Mines to conduct an integrated study that elucidated the mechanisms of alkali species formation and deposition and developed guidelines for use by plant operators to avoid deposition problems. An on-going collaboration between Sandia, NREL and, later, NETL continued the investigation of the formation and deposition mechanisms. Results of these studies have been of great use in ongoing experiments being carried out by industry.

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[1]Excerpted from *2001 EERE STRATEGIC PROGRAM REVIEW Biopower*, DOE

[2] *The Biopower Roadmap*, Office of Power Technologies, May 2001 (draft)

For cofiring to see widespread use, a number of technology-related issues must be resolved. Some, but not all cofiring tests have resulted in significant NO_x reductions. The mechanisms responsible for these reductions need to be identified and taken advantage of. It must be demonstrated that a variety of biomass feedstocks can be effectively burned in the full range of coal boiler types. This demonstration will allow these plants the fuel flexibility that the existing industry has demonstrated is necessary for economic viability. There is some concern that components of some biomass feedstocks may reduce the efficiency and effectiveness of systems for the selective catalytic reduction of NO_x (SCR systems). This could be a significant technical barrier to market penetration of cofiring. The existence of this problem must be confirmed or refuted and, if valid, guidelines must be developed for biomass feedstock compositions as well as possible cost-effective methods for eliminating the harmful components.

Gasification

In the longer term, gasification technologies hold the most promise for next-generation power generation efficiency improvements from combined cycles and fuel cells, as well as for production of high value co-products along with power generation. DOE has had a notable success with the FERCO Vermont gasifier project by successfully operating its commercial scale demonstration plant. This gasifier has since proven to be even more efficient than it was first thought to be in that the gasifier throughput has been in excess of 175 percent of the original design.

For this technology class to flourish, however, a number of technical barriers must be overcome. These include scale-up of the technology, replication of successful demonstrations and technologies that will aid in the integration of gasification systems with gas turbines and fuel cells. Existing technologies such as scrubbing can accomplish gas cleanup, but to achieve maximal efficiencies with minimal environmental impact, other options such as tar cracking must be developed to enhance the removal of tars and condensable organics. Some of the technical issues with conversion devices (turbines and fuel cells) have been at least partially addressed by efforts such as the DOE Clean Coal Program; however, these must be adapted for use with biomass.

Small Systems

A significant number of the world's 2 billion people who lack access to electricity have available substantial quantities of biomass resources but lack the means to convert this resource into electricity in a clean, reliable, and efficient manner. In addition, in the developed world, distributed generation is receiving increased attention as a way of increasing energy reliability as well as the efficiency of the transmission and distribution system. To be economically competitive and environmentally acceptable, a new generation of small biopower systems is being developed. These will couple biomass conversion devices (combustors and gasifiers) to conventional and advanced electricity generators such as microturbines, Stirling engines, and eventually fuel cells. These systems must overcome a number of technical issues including reliable and automated feeding and operation, reliable small-scale combustor and gasifier system development, small-scale gas cleaning systems and emission reduction methodologies. As an example, research at NREL has shown that CO and NO_x emissions from a gasifier/internal combustion engine system (a very common system in the developing world) can be substantially reduced

below equivalent emissions on natural gas by carefully tuning engine operating parameters and using a medium heat content gas.

Feedstock Production, Harvest, Transport, and Preparation

All biomass energy systems have the economic and energy cost of producing, transporting, and preparing the biomass feedstock as technical barriers. Significant progress has been made in this area, but to be truly economically competitive, new feedstocks and methods for their harvesting and preparation must be developed. In addition, harvesting, preparation, transportation, and feeding of a variety of biomass feedstocks that are suitable for power production must be demonstrated and new methods developed for reducing costs and energy requirements must be verified. This will reduce the delivered cost of feedstock to the energy facility to a level more competitive with fossil fuels as well as increase the return to the farmer producing the biomass.

Institutional

The commercial development of renewable energy technologies can be impeded by barriers that do not involve technical aspects of a given technology. Technological progress that improves performance or increases system efficiencies can open doors to deployment; however, market issues ultimately depend on overcoming the institutional challenges that these technologies will face. It can be far more difficult to put into place the necessary institutional mechanisms that will drive these commercial efforts. The keys to the successful implementation of energy technologies, and in particular, biopower technologies, are overcoming issues that can be categorized as the following:

–Regulatory
–Financial
–Infrastructural
–Perceptual

These categories were first developed in *The Potential of Renewable Energy: An Interlaboratory White Paper*, by INEEL et al, prepared for the Department of Energy, March 1990.

Regulatory

Through the regulatory process, governments direct activities in the broader societal interest. Regulations usually pertain to two broad issues: (1) markets and (2) health, safety, and environmental protection. Regulatory factors can create technology development opportunities that would not exist in unregulated environments. Within the United States, for example, the passage of the Public Utilities Regulatory Policy Act (PURPA) in 1978 required electric utilities to buy power from independent power producers and was designed to encourage small-scale electric power production from renewables, cogeneration, and energy conservation. This law has been considered by some analysts to be "the single most important spur to creation of a commercial renewable power market...".[3] During the 1980s, biomass power capacity rapidly expanded as a result of laws mandating that utilities purchase power from suppliers under contracts based on avoided power generation costs (as specified under PURPA). These contractual prices were substantially higher than current wholesale power prices, and permitted biomass projects to be financed and operated at a profit.

In the 1990s, changes in the electric power industry due to massive restructuring resulted in lower avoided costs and as present contracts are concluded, this biomass generation could be at risk. The closing of high cost power plants and the introduction of high-efficiency natural gas facilities are also

[3] Silverman, Murray and Susan Worthman, The Future of Renewable Energy Industries, *The Electricity Journal,* March 1995)

putting considerable downward pressure on electricity prices. In the United States and some other countries, utilities are breaking into multiple companies that compete for the power generation, transmission, distribution, and on-site elements of the power market. The eventual impacts of these and other trends on individual power producers are not yet clear. However present trends suggest that profit margins will be even tighter in the future. This atmosphere of heightened competition has already had the effect of reducing the willingness of power companies to take risks with new technology and to use renewable energy resources.

Although this situation presents challenges, the restructuring of the power industry is also providing new opportunities for biopower. Markets are developing for "green power," where electricity from selected generation sources can be sold at high prices (typically 1-2 cents per kilowatt-hour). Through consumer choice, green markets offer opportunities to expand the use and future development of renewable technologies. Increased biopower is also being encouraged through Renewable Portfolio Standards (RPS) established by state regulatory agencies. These standards require utilities to provide certain percentages of power, typically 5-10 percent, from renewable sources. Recognizing that these market-driven forces are currently undergoing clarification, the Biopower Program participates with environmental groups (such as Green-e) to resolve issues such as defining "green power" and understanding the public perception of biomass conversion technologies. Despite this progress, state and market incentives for biopower only exist in certain states. In addition, Federal, state and municipal policies and definitions with regard to green power and qualifying biopower technologies (e.g. some states and municipalities only include landfill gas) need to be harmonized to create a robust portfolio standard. This could lead to increased acceptance of biopower and resultant grassroots demand for increased deployment.

In the United States today, the regulations that control the release of oxides of sulfur (SO_2) and nitrogen (NO_x) are rapidly tightening under a variety of cap and trading schemes now being proposed for pollutants, particularly for NO_x. These regulations may work as a potential boon to biopower because biopower technologies such as cofiring improve utilities' emissions profiles in SO_x and NO_x. However, in some instances, EPA regulations and policies discourage existing coal plants from cofiring by opening them up to New Source Reviews if they modify their existing plants to accept biomass. The Biopower Program is currently collaborating with environmental regulatory bodies such as the EPA to reduce regulatory uncertainty related to NSR and emissions. This is a critical issue because there are more than 200 companies outside the wood products and food industries that generate biopower in the U.S. Where power producers have access to very low cost biomass supplies, cofiring is an attractive option for power companies to save fuel costs and earn emissions credits.

In the future, the potential regulation of greenhouse gas emissions will likely result in a particular advantage for the carbon dioxide-neutral biopower technology.

Financial

Financial constraints pertain to the availability and cost of a project and to the overall financial attractiveness of renewable energy technologies. Capital markets generally perceive the deployment of emerging technologies as involving more risk than established technologies. The higher the risk, the higher the rate of return demanded on capital thus impacting the rate of investment in these new, emerging technologies. Although the Biopower Program has worked to respond to these constraints through collaborative cost-sharing arrangements with developers, more needs to be done such as accelerating capital depreciation to facilitate investments in new technologies.

Tax incentives for renewable energy technologies have been passed by Congress to offset their higher tax burden and the hidden costs of fossil fuels. Under the Energy Policy Act of 1992 (EPACT), electricity production from wind and biomass grown from energy crops became eligible for a 1.5 cents/kWh production incentive, available for 10 years. Yet this production incentive is overly restrictive as EPACT provisions only allow for "closed loop biomass" (crops grown exclusively for power generation). The Program is hopeful that pending legislation will expand to include open loop biomass with a broader definition of qualifying feedstocks. To date, in the biomass area, ethanol is the main beneficiary of tax policy. While that may change under the President's National Energy Plan with the revisiting of Section 29 tax credits for landfill gas, tax credits need to be expanded to open loop firing and cofiring.

Infrastructural

Infrastructure is a general term for the entire energy service production and delivery system. It involves decisions made by a broad range of players including consumers, energy service providers such as utilities, fuel suppliers, and others. The nature of the biomass technology requires the need for infrastructure for the supply of feedstocks and for distributing products. Unlike fossil fuels such as coal and natural gas, which have a highly developed and sophisticated infrastructure in the U.S via railroad transportation and pipelines, a similar infrastructure does not currently exist for biofuels.

At this time, the biomass supplies are dominated by low-cost residues streams. The residue stream consists of materials self-generated by industries that process biomass for fiber or food uses (such as paper mills, lumber mills, sugar mills, etc.) or other economic activities (agriculture, urban construction and demolition, rate of waste generation, etc.). The quality, quantity, and cost of these resources continually vary in response to economic growth rates, discount factors, and regulation, e.g., the regulation of landfill activity and policies towards recycling.

In the future, a dedicated feedstock supply system based on short-rotation woody crops and herbaceous perennial crops could dramatically expand the assured availability of biomass for energy applications. The Biopower Program is working with Oak Ridge National Laboratory through the Bioenergy Feedstock Development Program to help expand the supply of these energy crops. Furthermore, establishing a Biomass Reserve Program (BRP) of perennial tree and grass crops that are particularly suitable for low-quality cropland, like that currently enrolled in the Conservation Reserve Program (CRP), could help to remove some infrastructural barriers related to the cost and supply of feedstocks. DOE will collaborate with USDA to assess the potential for using CRP-like programs to produce both energy and environmental benefits from investments in agricultural programs.

Another problem associated with the technology infrastructure concerns the 50-mile supply radius for the economic collection and transportation of fuel. In the future, the development of new technology (Fischer-Tropsch) that allows for the conversion of biomass into a liquid may allow for the feedstock to be transported more cost-effectively at greater distances. In the meantime, small modular systems are being looked at for distributed applications. These systems are less than 5 MW and can be transported directly to the feedstock production site.

Perceptual

The Biopower Program has a number of activities related to outreach, technology transfer, education and communication, as there is a lack of familiarity with biomass power technologies by the public and government and industry decision makers. Many people still do not know what the term "biomass" means, let alone understand the benefits and new technology developments associated with biomass. In addition, some environmental groups do not view biomass as a "green" technology. Awareness of biomass tends to be associated with wood stoves and concerns over emissions from the combustion of wood than with biomass as an alternative energy technology. Less is known by the public and others about the low emissions, high efficiency, and environmental benefits offered with state-of-the-art biomass power systems. There are also concerns related to harvesting of trees as well as the need for sustainable supply. These unfavorable perceptions translate into financial costs and risks to any biomass project. Only with considerable education efforts and demonstration that environmental concerns are being accounted for can the risks of nonacceptance be overcome. In terms of these perceptual barriers, the program is examining a number of activities to educate and disseminate better information on the benefits of biopower to industry, regulators, environmental organizations, and the public to gain appreciation for bioenergy and, in turn, harness support for biopower-friendly policies.